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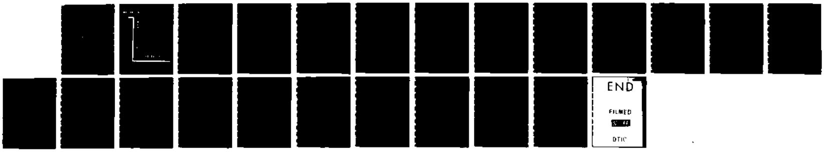

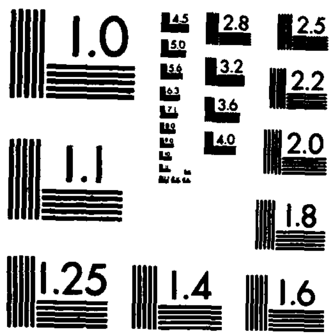

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AIR FORCE HUMAN RESOURCES LABORATORY

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COMMAND AND CONTROL DECISION-MAKING RESEARCH

By

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Wright-Patterson Air Force Base, Ohio 45433

January 1984

AIR FORCE SYSTEMS COMMAND
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NOTICE

This paper has been reviewed and is approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The text of the presentation is divided into two parts. In part one, the tactical command and control organization of the USAF -- the Tactical Air Control System -- is briefly discussed. The second part of the presentation provides a brief overview of the in-house combat-planning simulation system at the Air Force Human Resources Laboratory (AFHRL). This research apparatus, known as the Tactical Battle Management Software, is a multi-user, interactive system with on-line data recording capability. The role of this experimental device in the AFHRL research effort in the area of tactical decision making is briefly outlined.

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Chief, Ground Operations Branch

Paper presented at the 26th Annual Meeting of the Human Factors Society,
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COMMAND AND CONTROL DECISION-MAKING RESEARCH[1]

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Introduction

We have been asked to contribute to this workshop by describing the ongoing work at the Air Force Human Resources Laboratory in the area of tactical decision making. Before proceeding with the main body of the presentation, some qualifying and limiting remarks need to be stated. First, command and control (C^2) can be dichotomized into strategic and tactical components. In this context, strategic C^2 refers to intertheater operations and tactical C^2 refers to intratheater operations. Our work, to date, has been confined to the tactical C^2 arena. Second, tactical C^2 is implemented in different ways across the military services. The focus of this presentation shall be confined to Air Force tactical C^2.

Given these qualified statements, we can ask just exactly what is meant by Air Force tactical C^2 and how the decision-making research planned by the Air Force Human Resources Laboratory fits into this "picture." In the first part of the presentation, we will attempt to answer the former question and in the second part, the latter question.

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[1]Paper presented at the 26th Annual Meeting of the Human Factors Society, October 25-29, 1982, Seattle WA.

Part I: The Tactical Air Control System

In the USAF, the term "tactical C^2" refers to the Tactical Air Control System (TACS). Broadly speaking, the Tactical Air Control System is composed of several organizational "elements" with unique, but interrelated, functions (Figure 1).

The highest element in this hierarchical organization is the Tactical Air Control Center (TACC). Two of the major subordinate elements to the Tactical Air Control Center are the Control and Reporting Center (CRC), and the Air Support Operations Center (ASOC). Generally speaking, the Tactical Air Control Center functions in a "command" role while the Control and Reporting Center and the Air Support Operations Center, together with their subordinate elements, function in a "control" role. We say "generally speaking" because this is not strictly true. There are varying degrees of both "command" and "control" at all levels throughout the Tactical Air Control System. However, in order to prevent us from getting lost in detail, we will characterize the Tactical Air Control Center as primarily a "command" oriented element and the Control and Reporting Center and the Air Support Operations Center as "control" oriented elements. The entities that are "commanded" and "controlled" by the Tactical Air Control System are the executing agencies of the Air Force: the wings and squadrons which are tasked to accomplish combat-related missions. Thus, we can say that one of the major missions of the Tactical Air Control System is the effective use of air power through the processes of "command" and "control."

We will now attempt to describe the context in which the Control and Reporting Center and Air Support Operations Center -- with their subordinate elements -- function. We will then return to a more detailed discussion of the Tactical Air Control Center -- the focus of our planned

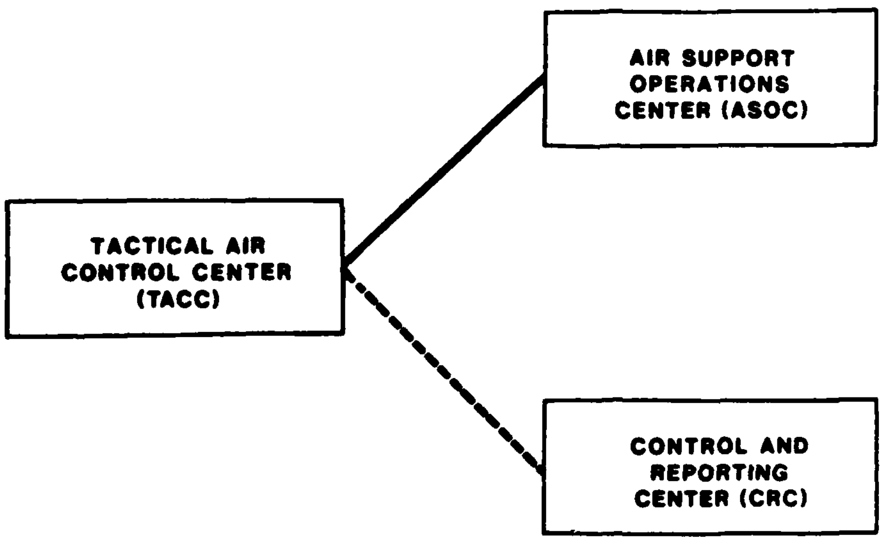

Figure 1

Major "elements" of the Tactical Air Control System.

research efforts. Again, please keep in mind that the detail of these descriptions is at a general level and, by necessity, will be incomplete. The purpose is solely to convey general ideas and concepts.

The Control and Reporting Center and its subordinate elements accomplish air surveillance and intercept-related missions (Figure 2). The forward-most elements of this aspect of the Tactical Air Control System are the Forward Air Control Posts (FACPs). By "forward-most" elements, we mean that the Forward Air Control Posts are the closest to "the front" -- normally referred to as the Forward Edge of the Battle Area (FEBA). Further back from the Forward Edge of the Battle Area are the Control and Reporting Posts (CRPs). The Control and Reporting Posts, in turn, are subordinate to the Control and Reporting Center. As can be seen, these elements have overlapping radar coverage, the purpose of which is to detect airborne threats and attempt to neutralize these threats with air-to-air or surface-to-air weapons. Obviously, Figure 2 is incomplete; not shown are the roles of the Airborne Warning and Control System (AWACS) and the ground-based air-defense systems in this organizational scheme.

Another major subordinate element of the Tactical Air Control Center is the Air Support Operations Center. The Air Support Operations Center and its own (functional) subordinate elements -- the Tactical Air Control Parties (TACPs) -- are Air Force organizations that are collocated with ground forces. The TACPs depicted in Figure 3 are collocated, from right-to-left, with Army battalion, brigade, and division command posts, respectively. The ASOC is usually located in the vicinity of an Army corp command post. The Air Force personnel in these elements advise the local ground-force commanders on the effective use of air power, serve as the local liaisons in the immediate air-support request net, and are the final point of contact for pilots carrying out air-to-ground missions in

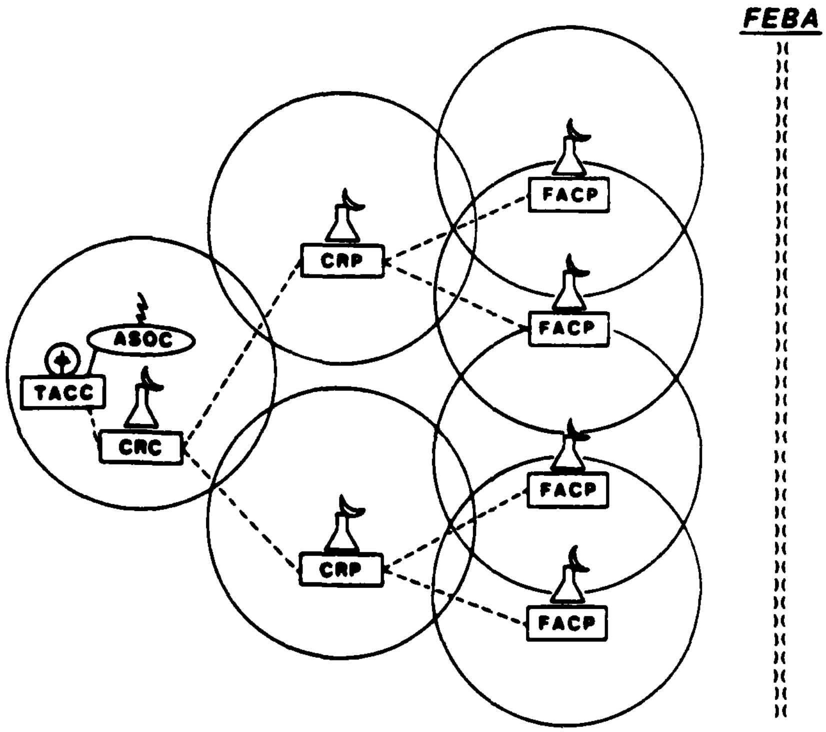

Figure 2

Air-surveillance portion of the Tactical Air Control System.

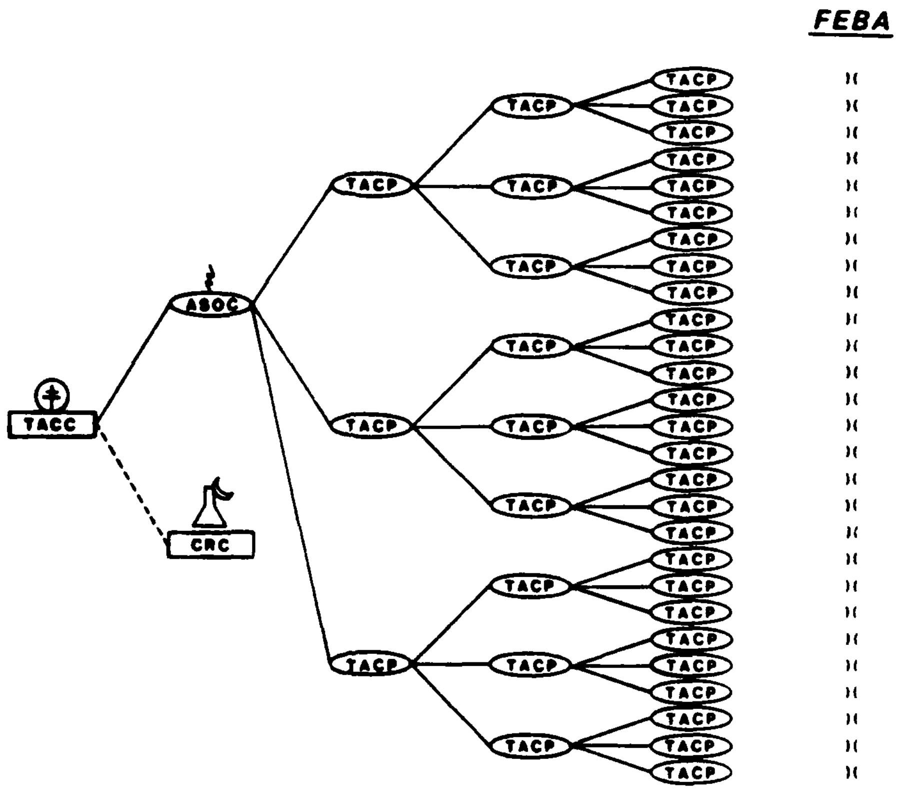

Figure 3

Ground-operations support portion of the Tactical Air Control System.

support of ground troops. As with the air-surveillance aspect of the Tactical Air Control System, the ground-operations support aspect of the Tactical Air Control System shown in Figure 3 is also incomplete. Not shown, for example, are elements such as the Air Support Radar Team (ASRT).

If Figure 2 was superimposed over Figure 3, the complex organizational structure of the Tactical Air Control Sy ould become readily apparent. For obvious reasons then, we shall t discuss the interactions among the elements and subelements of t Tactical Air Control System or the communications network in which the embedded.

The aircraft which are used for air-defense and ground-operations support missions are placed under the control of the Control and Reporting Center and Air Support Operations Center, respectively, by the Tactical Air Control Center. Air-defense missions are technically termed Defensive Counter Air (DCA) mission. The type of Defensive Counter Air mission depicted in Figure 4 relies on an approach that places a certain number of air-to-air capable combat aircraft at a particular orbit location. If enemy aircraft are detected by the air-surveillance "arm" of the Tactical Air Control System, then some of these fighters are directed to intercept and engage the transgressing enemy aircraft.

The other mission type that we previously alluded to -- ground-operations support missions -- are technically referred to as Close Air Support (CAS) missions. As can be seen in Figure 4, these missions are conducted directly over the Forward Edge of the Battle Area in support of ground troops. Requests for this type of air support are passed from field commanders to the Tactical Air Control Parties. The Tactical Air Control Parties, in turn, transmit these requests to the Air Support Operations Center where the most suitable "alert" aircraft armed

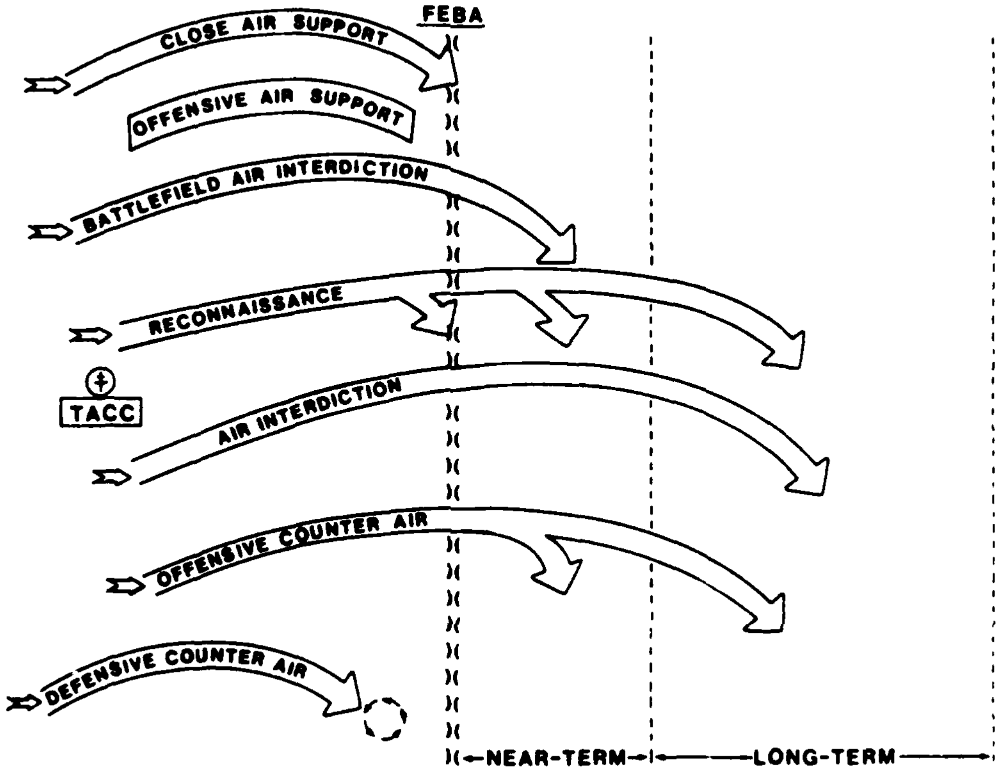

Figure 4

Example of some of the different mission types tasked at the Tactical Air Control Center.

with the most appropriate ordnance are tasked to accomplish the requested missions.

The other mission types shown in Figure 4 are Battlefield Air Interdiction (BAI), Reconnaissance, Air Interdiction (AI), and Offensive Counter Air (OCA). The purpose of Reconnaissance missions should be fairly obvious, and we shall not discuss this mission type. The purpose of Battlefield Air Interdiction and Air Interdiction missions is to reduce the enemy's assets which may be "brought to bear" on the Forward Edge of the Battle Area in the near-term and in the long-term, respectively. Obviously, "near-term" and "long-term" are relative terms. It would not be unreasonable, however, to think of "near-term" as the 0- to 24-hour time frame and "long-term" as the 24- to 72-hour time frame. An example of a Battlefield Air Interdiction target may be second echelon enemy ground forces and an example of an Air Interdiction target may be some type of bridge that is critical to the movement of the enemy's war materiel to the front. The final mission type depicted is Offensive Counter Air. In general, the purpose of Offensive Counter Air missions is to reduce the effectiveness of the enemy's air power to the extent that friendly forces can carry out their missions without prohibitive interference. Aircraft are assigned to the mission categories described above through the processes of apportionment and allocation. Simply stated, apportionment refers to the percentage of the total aircraft[2] allocated to each mission category and allocation to the breakdown of these percentages to specific numbers and types of aircraft.

[2] Strictly speaking, it is the number of "sorties," not the number of aircraft, that are apportioned. Broadly speaking, a sortie is one "flight" by one aircraft. A single aircraft is usually tasked for more than a single flight or sortie per day. Thus, it is the <u>total</u> number of flights or sorties that are apportioned.

Given the preceding discussion, we are now in a position to examine the Tactical Air Control Center in greater detail. As shown in Figure 5, the Tactical Air Control Center consists of four divisions: the Combat Operations Intelligence Division (COID), the Combat Planning Division, the Enemy Situation Correlation Division (ENSCD), and the Combat Operations Division. Two different, but interrelated, observations can be made with respect to the functional relationships among these four divisions. The first is that the Combat Operations Intelligence Division and the Enemy Situation Correlation Division are "intelligence" organizations whose functions include the support of the two "operations" divisions: the Combat Planning Division and the Combat Operations Division. The second observation is that the Combat Operations Intelligence Division and the Combat Planning Division are jointly involved in the planning for the next day's combat missions and the Enemy Situation Correlation Division and the Combat Operations Division are jointly involved in the monitoring, adjustment, and execution of the present day's missions. Thus, it can be said that the Combat Operations Intelligence Division and the Combat Planning Division function in a "projective" mode and that the Enemy Situation Correlation Division and the Combat Operations Division function in a "real-time" mode.

Following processes and procedures such as target analysis, weaponeering, and target nomination, the Combat Planning Division begins to schedule combat missions in the mission categories previously discussed (Close Air Support, Battlefield Air Interdiction, Air Interdiction, Offensive Counter Air, Defense Counter Air, and Recconaissance). Some aircraft are scheduled against specific targets while other aircraft are scheduled for availability in given time-blocks. The aircraft scheduled into these time-blocks are said to be on "alert" status and it is these aircraft that are scrambled by the Air Support Operations Center and the Control and Reporting Center in response to immediate enemy threats.

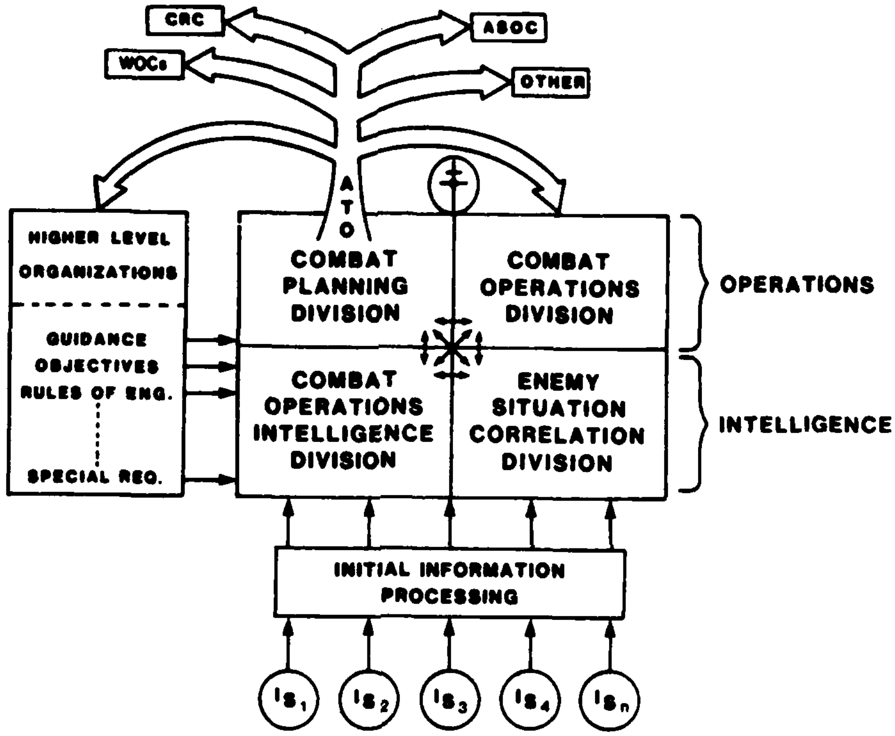

Figure 5

The four divisions of the Tactical Air Control Center.
ATO: Air Tasking Order
WOC: Wing Operations Center
I_{S_1} .....I_{S_n} : Information Sensors

Let us now focus in more detail on the Combat Planning Division and examine how these missions are scheduled. As shown in Figure 6, the Combat Planning Division is composed of a number of branches, each consisting of a branch chief and various planners. Even though each branch is tasked with the planning of certain types of missions, it should be pointed out that there is considerable interaction among the branches. The obvious implication here is that the planning process is a joint, interactive effort on the part of all the branches of this division.

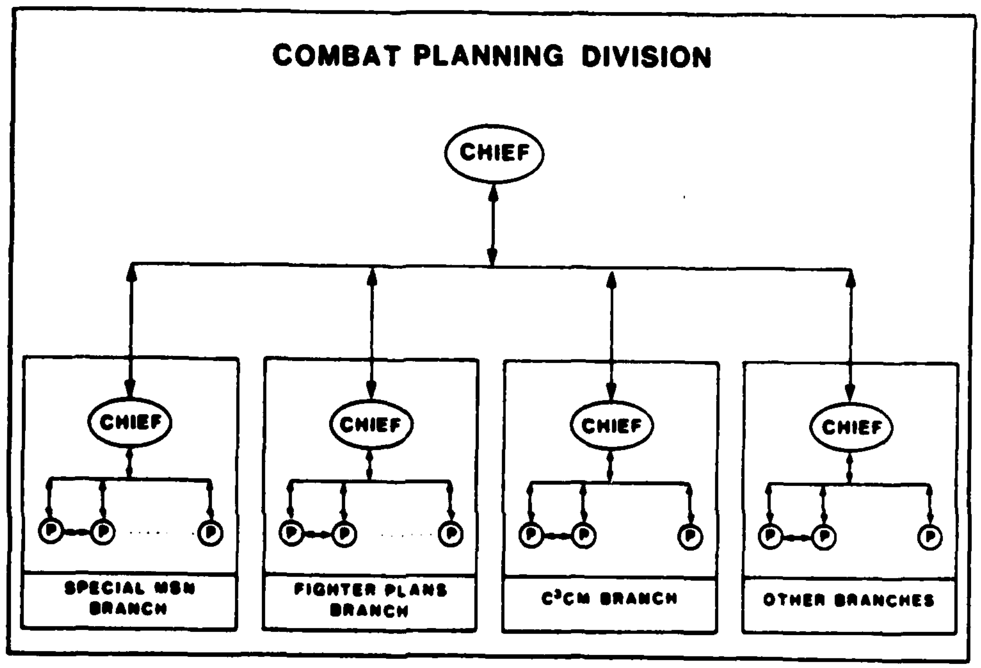

Figure 6

Branches of the Combat Planning Division.
P: Combat Planner

Part II: The AFHRL Research Effort

The focus of the research effort reported here is on the Fighter Plans Branch of the Combat Planning Division. In order to make the problem tractable, we have further limited our efforts to the examination of decisions involved in the planning of Offensive Counter Air missions. As mentioned previously, the general intent of Offensive Counter Air missions is to reduce the effectiveness of the enemy's air power to the extent that friendly forces can carry out their missions without prohibitive interference. Examples of Offensive Counter Air targets are enemy airbases, early-warning radar installations, and ground-control intercept radar installations. In order to gain an appreciation for the complexity involved in the scheduling of Offensive Counter Air missions, let us consider some of the decision factors which are involved in this process.

Some of the factors that we have thus far uncovered as a result of our discussions with combat planners is depicted in Figure 7. We do not claim, however, that this is an exhaustive list. Nevertheless, we believe that this figure adequately portrays the state-of-affairs in the Fighter Plans Branch. Given the complexity of this decision situation and the minimal decision (as opposed to procedural) training presently provided, we can pose questions such as whether the quality of tactical decision making is at an acceptable level and whether training programs can improve the quality of tactical decisions regardless of present levels of performance.

In order to provide some preliminary answers to these kinds of questions in the context of Offensive Counter Air missions, at least two tasks need to be accomplished. The first, and most difficult, is the

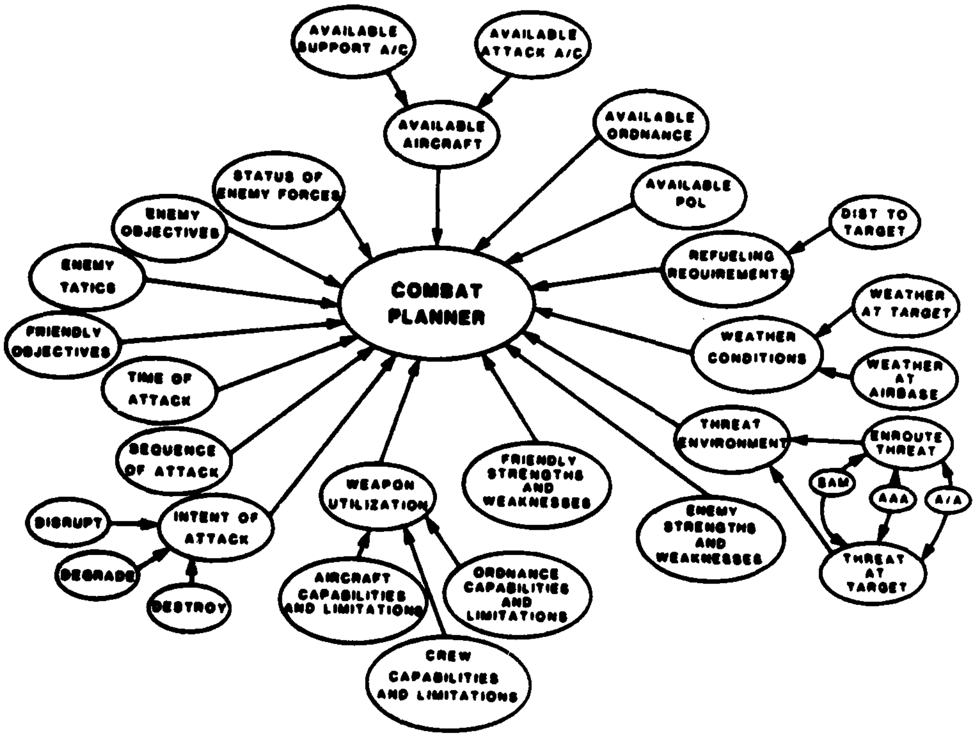

Figure 7

Some factors involved in the combat planning process.

development of an evaluation tool which can be used to assess the quality of tactical decision-making performance. In the final analysis, it is this tool that will provide us with an initial idea of how well tactical decision makers perform and the degree to which decision-making training programs could potentially improve tactical decisions. The second task which needs to be accomplished is the development of an experimental tool which can be used to collect both process and product data in simulated tactical decision-making situations. The data resulting from these types of experiments would then be assessed with the evaluation tool and would provide some initial guidance for the manner in which decision-making training programs could potentially improve tactical decisions. Presently, we are working on these two tasks in parallel. Because the development of our experimental tool is at a more advanced stage of development than our evaluation tool, we will now describe this aspect of our effort.

The experimental capability which we are developing can be viewed from two interrelated perspectives: hardware and software (Figure 8). In terms of the hardware, the centerpiece of our experimental simulation is a PDP-11/44 minicomputer which is interfaced to a Genisco GCT-6000 graphics computer and five VT100 alphanumeric terminals. In addition, the graphics computer is also interfaced to five graphics terminals. Thus, we have a total of five work-stations or test-stations, each consisting of one alphanumeric terminal, one graphics terminal, one keyboard, and one joystick. The time-sharing capabilities of this multi-user system can be configured in various ways. For example, up to five subjects will be able to work on five different problems at the same time, and as many as five subjects will be able to work on a single, common problem at the same time.

The system is completely interactive and has built-in software routines for the recording of session events and subject response times.

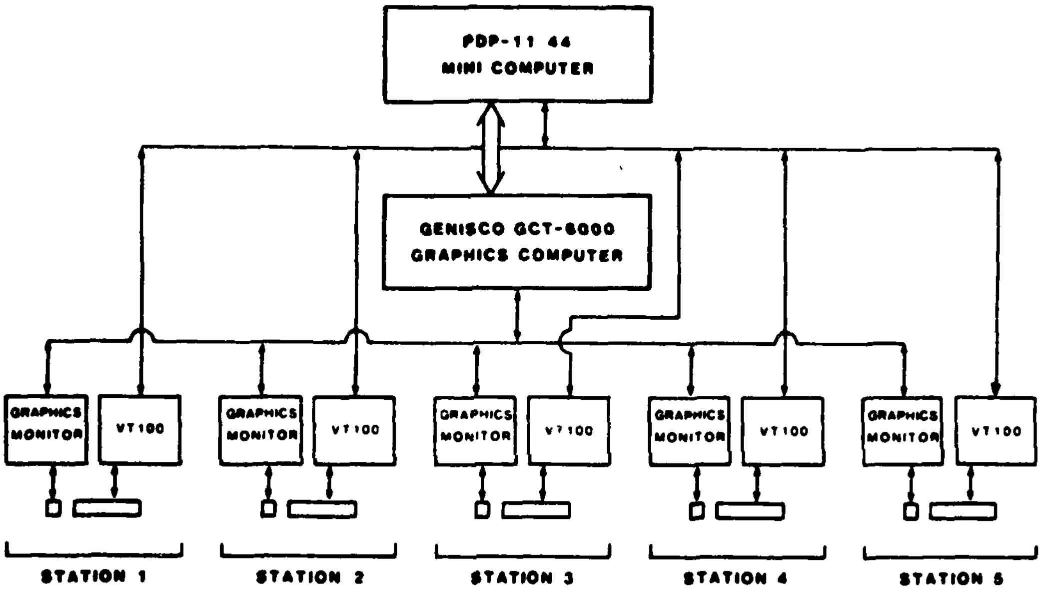

Figure 8

Tactical combat-planning simulation system.

Session events and subject responses can be thought of as being recorded in "frames." A *frame* is defined as the current stimuli (whatever is on the graphics and alphanumeric terminals), the subject's response or responses to these stimuli, the elapsed time from the presentation of new stimuli to the subject's first response, and the elapsed time from the subject's first response to the subject's last response in those cases where more than a single entry is required (e.g., the filling-in of a menu). It is these frames of information that will be analyzed in order that we may make inferences about the tactical decision-making processes involved in planning of Offensive Counter Air missions.

Our experimental approach, then, is somewhat similar to that used in verbal protocol experiments. However, rather than recording the subject's verbal reports during problem solving, we record the subject's manual interaction with the system. It should be noted that the system contains all the information that the subject needs for problem solution. In this way, we have eliminated a potential artifact which could falsely discriminate effective from ineffective decision makers: amount of knowledge. By embedding the data necessary for problem solution into the system, we have shifted the focus of our analysis from "how much" a subject knows, to the examination of data manipulation strategies. Furthermore, we will be able to quantify these strategies in terms of frequency, order, and pattern of data examination by the subject. The examination of decision time, inferred from response time, is an additional dependent measure that may shed light about the characteristics of the decision-making process. It is our expectation that this approach has the potential to result in the type of process and product data that could guide us in future decisions about the need for decision-making training programs, how these programs should be conducted, and the direction of further experimental efforts.

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